Characterization of Water Vapor in the North American Monsoon with JLH Mark2 and Aura MLS

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Introduction

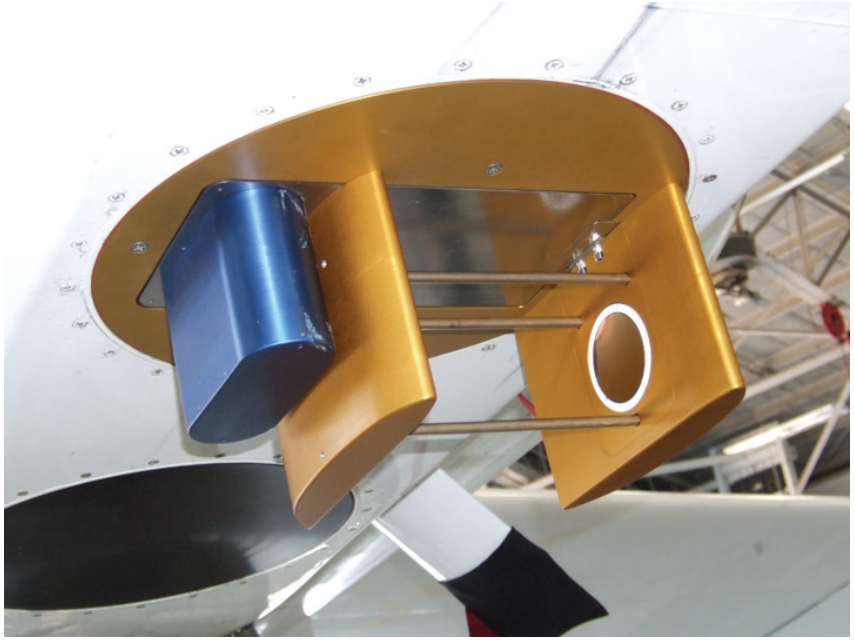
- Overshooting tops are a significant source of water vapor in the mid-latitude lower stratosphere [Dessler et al., 2002; Corti et al., 2008].
- Recent publications have documented water convectively injected into the lower stratosphere. These observations include aircraft [Anderson et al., 2012] and Aura MLS [Schwartz et al., 2013].
- UTLS water enhancements over the U.S. are associated with the North American Monsoon (NAM), and are contained by the summertime anticyclone.
- This water influx has an impact on stratospheric ozone through photochemistry.
- We examine UTLS water vapor from Aura MLS and several JLH case studies from SEAC4RS.

Measurements used in this analysis

- JLH Mark2 water vapor (NASA ER-2).
- MMS pressure and temperature (NASA ER-2).
- ER-2 navigational data.
- Aura MLS water vapor.
- Back-trajectory calculations (Eric Ray).
- Overshooting tops data product (Kris Bedka).

JLH Mark2 Instrument

JPL Laser Hygrometer



- Redesigned optics for SEAC4RS flights.
- Athermal mechanical mounting for better optical stability.
- Aerodynamic mirror holders for better optical stability.
- Near-real time water produced during the SEAC4RS mission.
- Postprocessing from direct absorption spectra.
- HITRAN 2012 linelist.
- Data submitted for all 20 science flights.

JLH Mark2 Instrument

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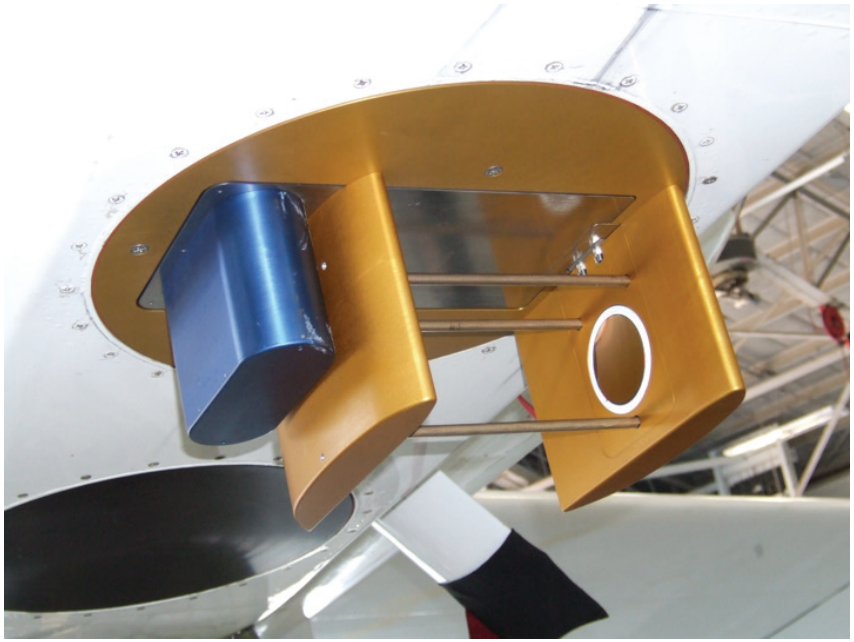


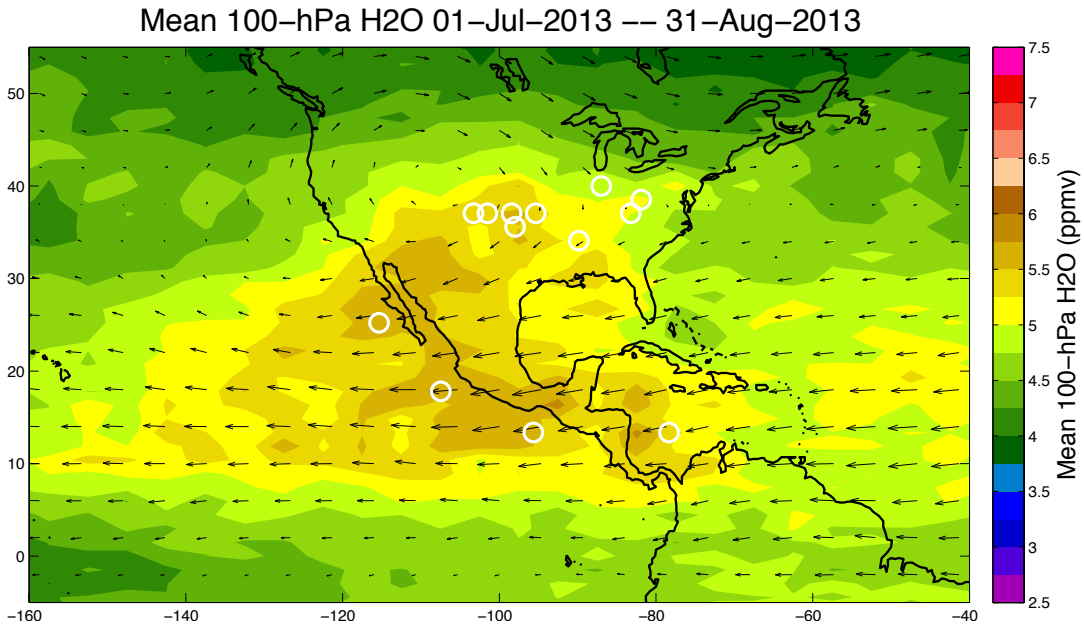
- Scan water line at 7299.43 cm^{-1}.
- Total optical pathlength: 1047.9 cm.
- Folded path between two mirrors.
- Accuracy ~ 10%

Outline

- Part 1: Observations
  - Aura MLS
  - JLH Mark2
- Part 2: Back-Trajectory analysis

Moisture during SEAC4RS

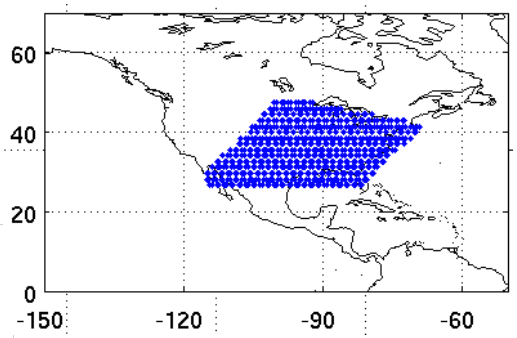
Aura MLS version 3.4 H_2O

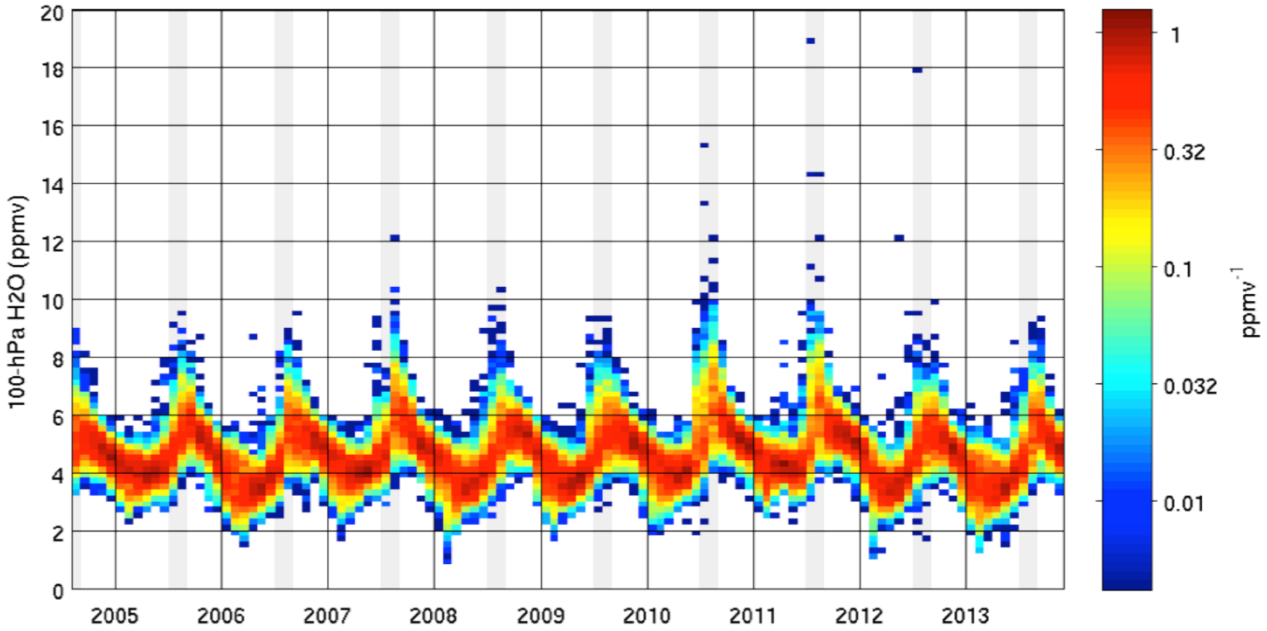


- Aura MLS 100-hPa H_2O (color scale), with superimposed MERRA horizontal winds (arrows) for July-August 2013 during the SEAC4RS time period.
- MLS observations of 100-hPa H_2O greater than 8 ppmv in this two-month period are shown by the white circles.

One decade of moisture over CONUS

Aura MLS version 3.4 H_2O





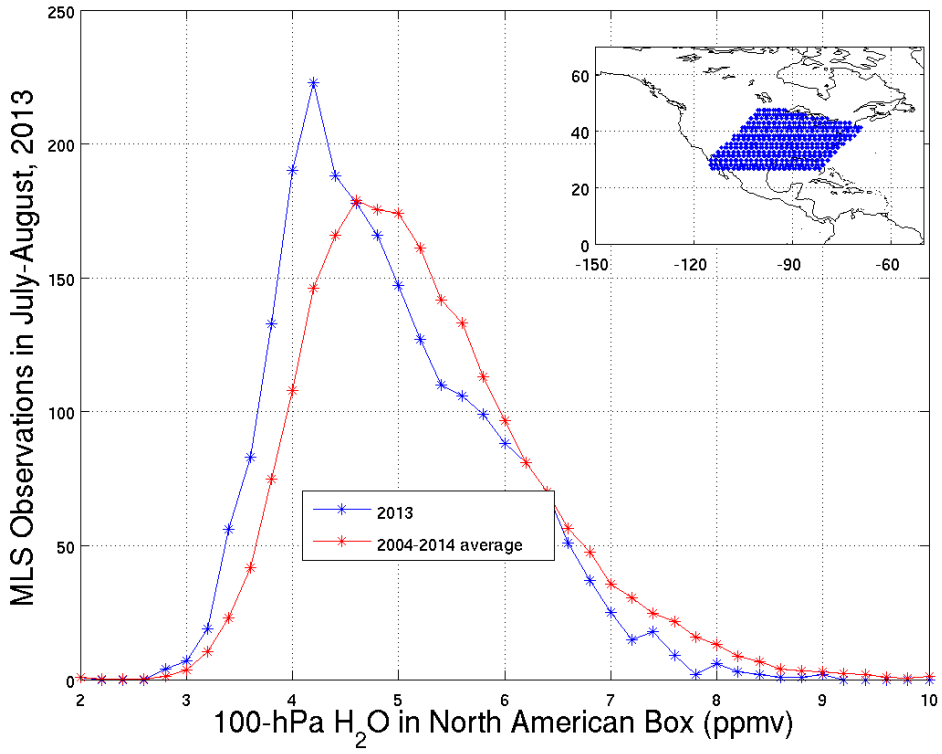
- Histogram of Aura MLS water vapor at 100-hPa, 2004 through 2013.
- July/Aug period shaded in gray.
- Summer 2013 had fewer extreme events than the previous three years.

Aura MLS new version 4.2

- Previous analysis was Aura MLS version 3.4.
- New H_2O prior is GMAO GEOS-5.9 (not 5.2)
- New improved low-resolution water vapor retrieval with more channels.
- The high-resolution water vapor retrieval uses the low-resolution profile for the prior, and for smoothing constraints.

Histogram of moisture at 100 hPa

Aura MLS version 4.2 H_2O



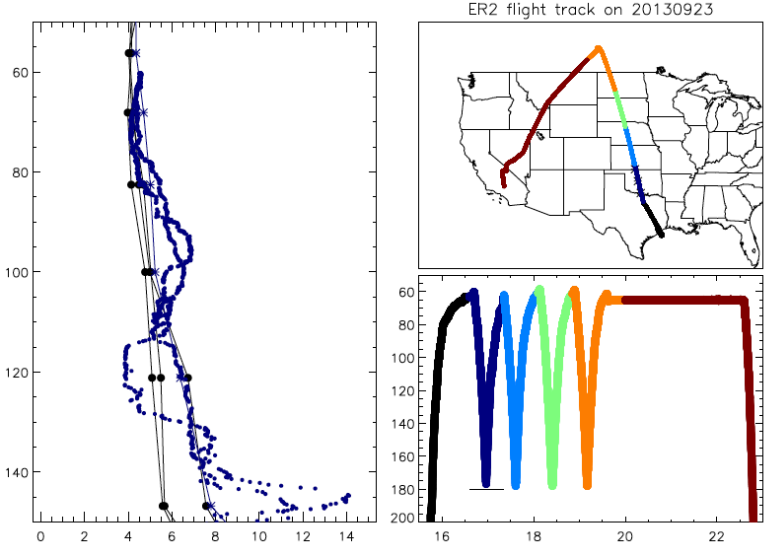
- For July-August at 100 hPa over the CONUS, 2013 was drier than the 11-year mean.

JLH Mark2 Airborne Measurements

- Instrument
- Intercomparison
- Case Studies (8/8, 8/14, 8/16, 8/27)

JLH Mark2 Intercomparison

JLH Mark2 and Aura MLS version 4.2



JLH Mark2 Intercomparison

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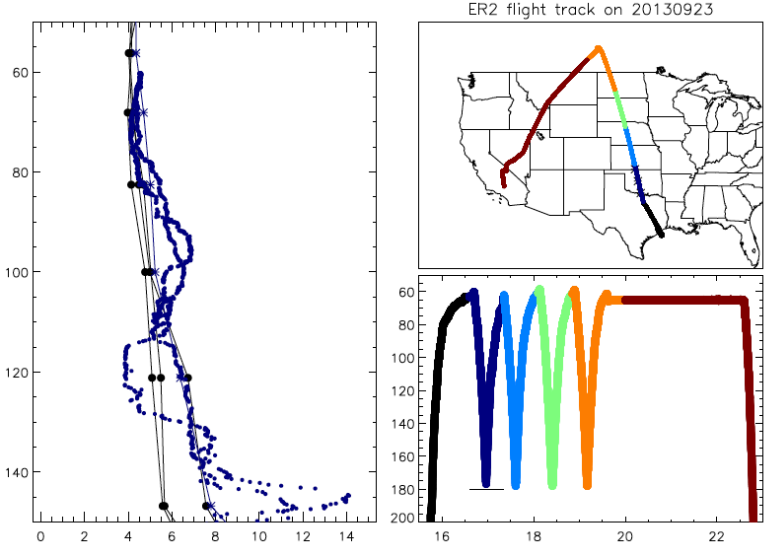

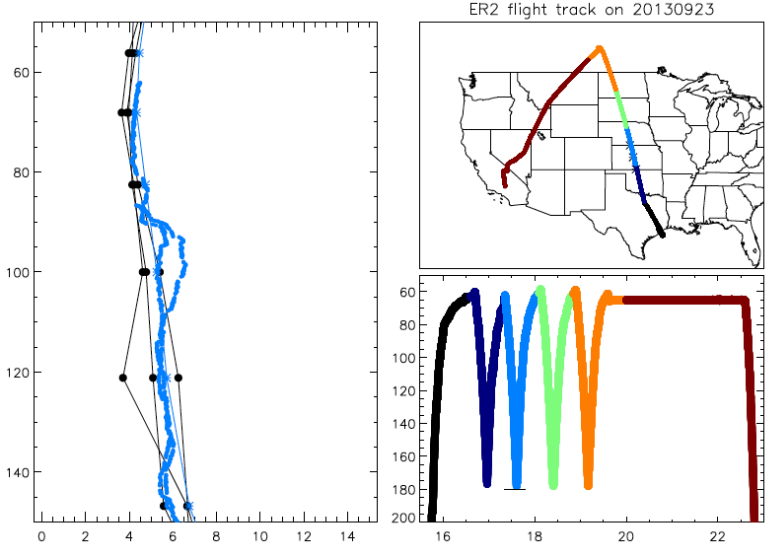

JLH Mark2 Intercomparison

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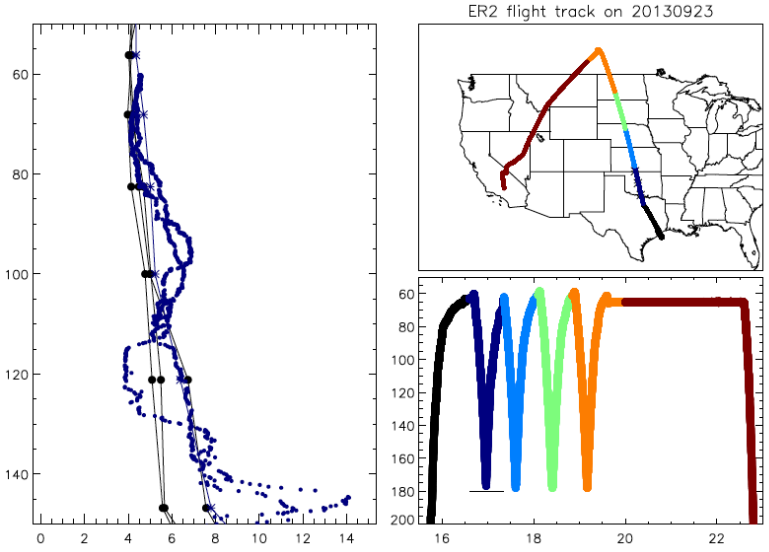

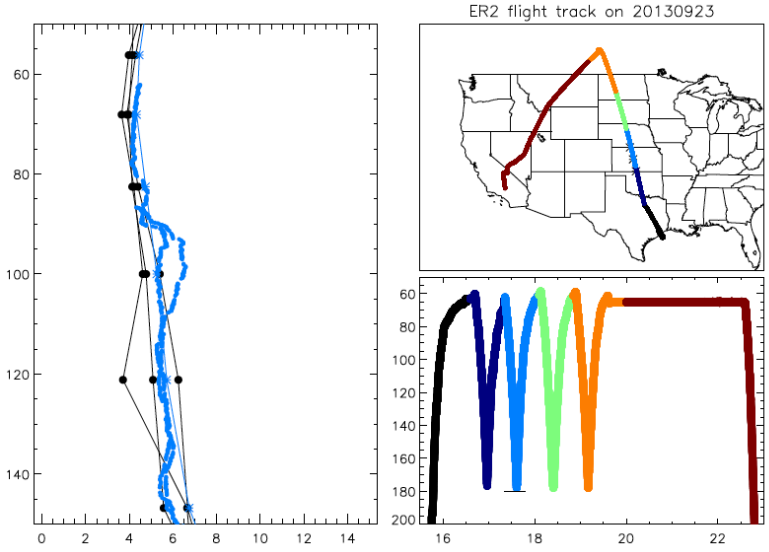

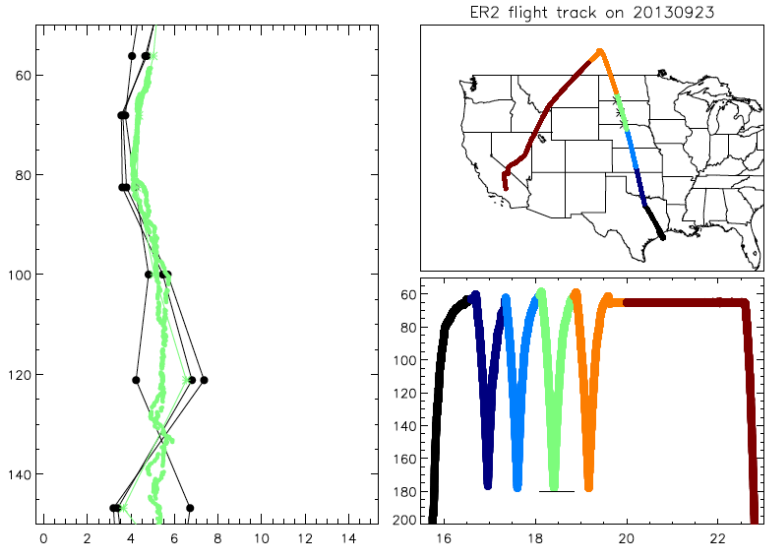

JLH Mark2 Intercomparison

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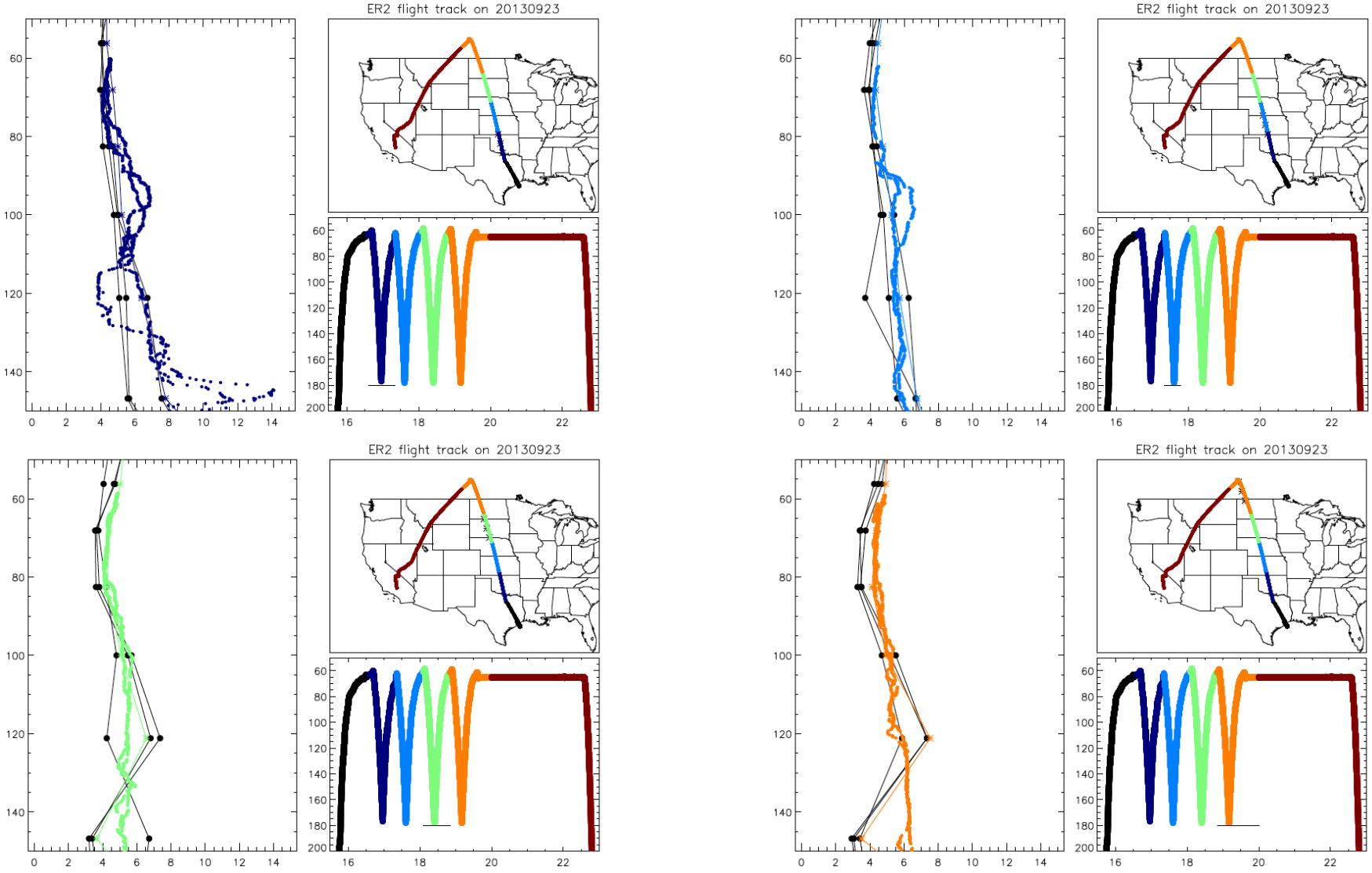

Case Studies

NASA ER-2 flights designed to intercept convective injections

- JLH Mark2 data shown.
- Similar results are seen from the other two hygrometers on the NASA ER-2, Harvard Lyman-alpha and HHH.
- 7-day back trajectory analyses from the ER-2 flight track.
- Overshooting cloud top data from Kris Bedka's analysis of satellite data.
- We see a connection between overshooting convection and enhanced water vapor at 80 to 160 hPa in the lower stratosphere.

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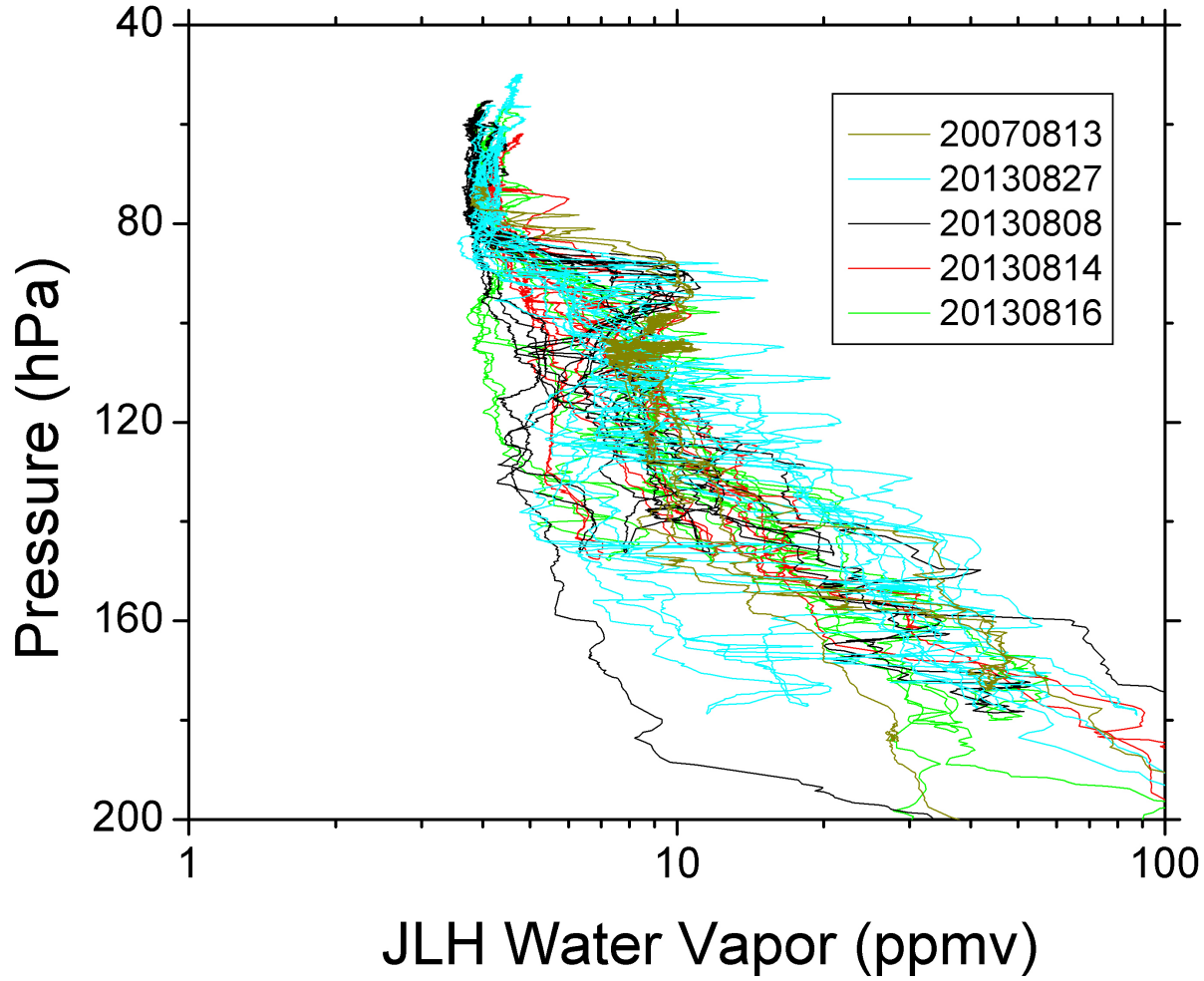
See tomorrow's posters:
Pat Minnis (for Kris Bedka), Climatology of Overshooting Cloud Top Detections Using MODIS and Geostationary Satellite Data.
Lenny Pfister, Convective Influence during SEAC4RS.
Eric Ray, Characteristics of Overshooting Convection.
David Wilmouth, Analysis of Convectively Injected H_2O and Potential Impact on Cl and O_3 over the U.S. in Summer.

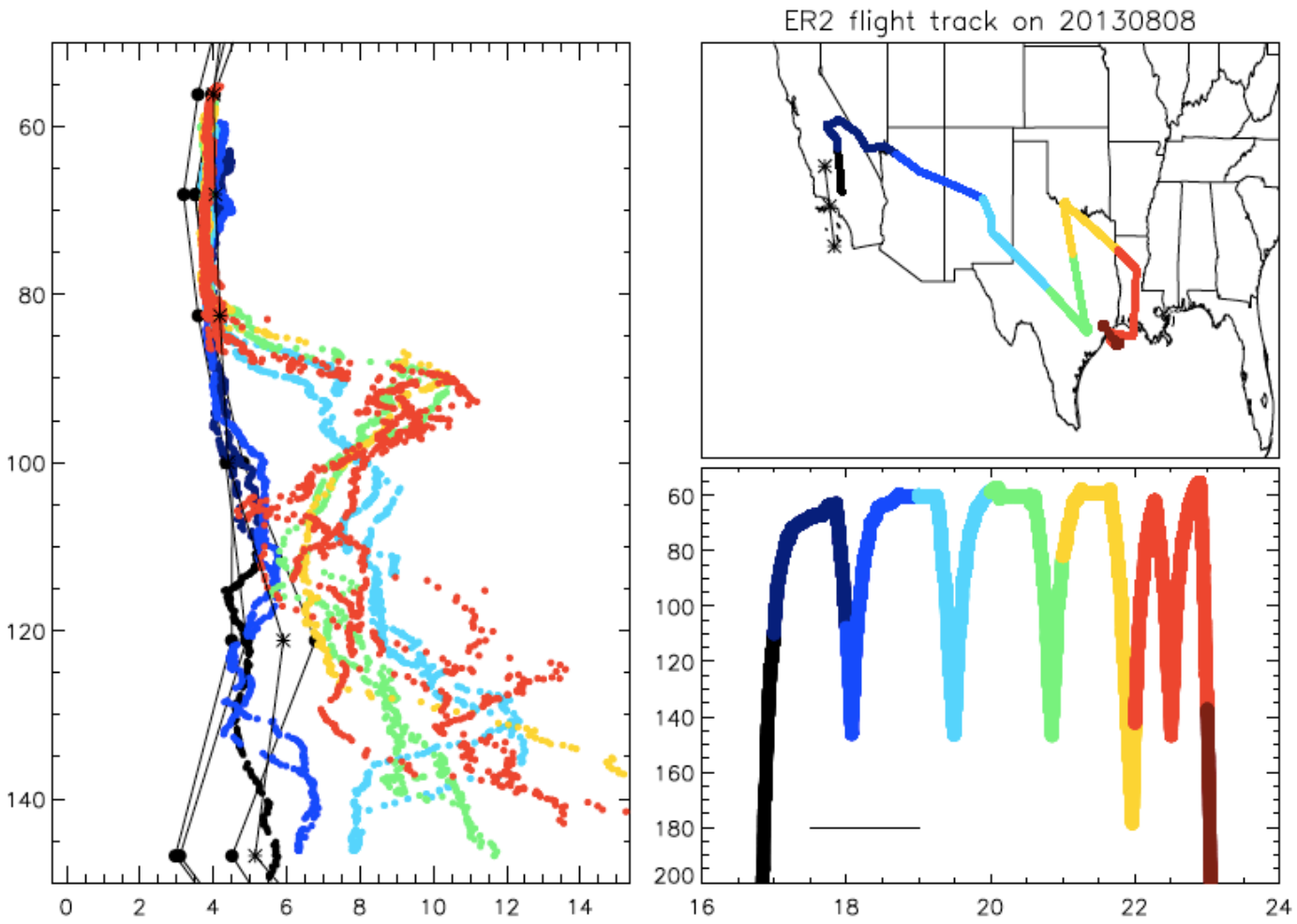
Case Studies

8/8, 8/14, 8/16, 8/27/2013 from SEAC4RS.



Case Study 1: 08/08/2013 transit flight

JLH Mark2 and Aura MLS v4.2



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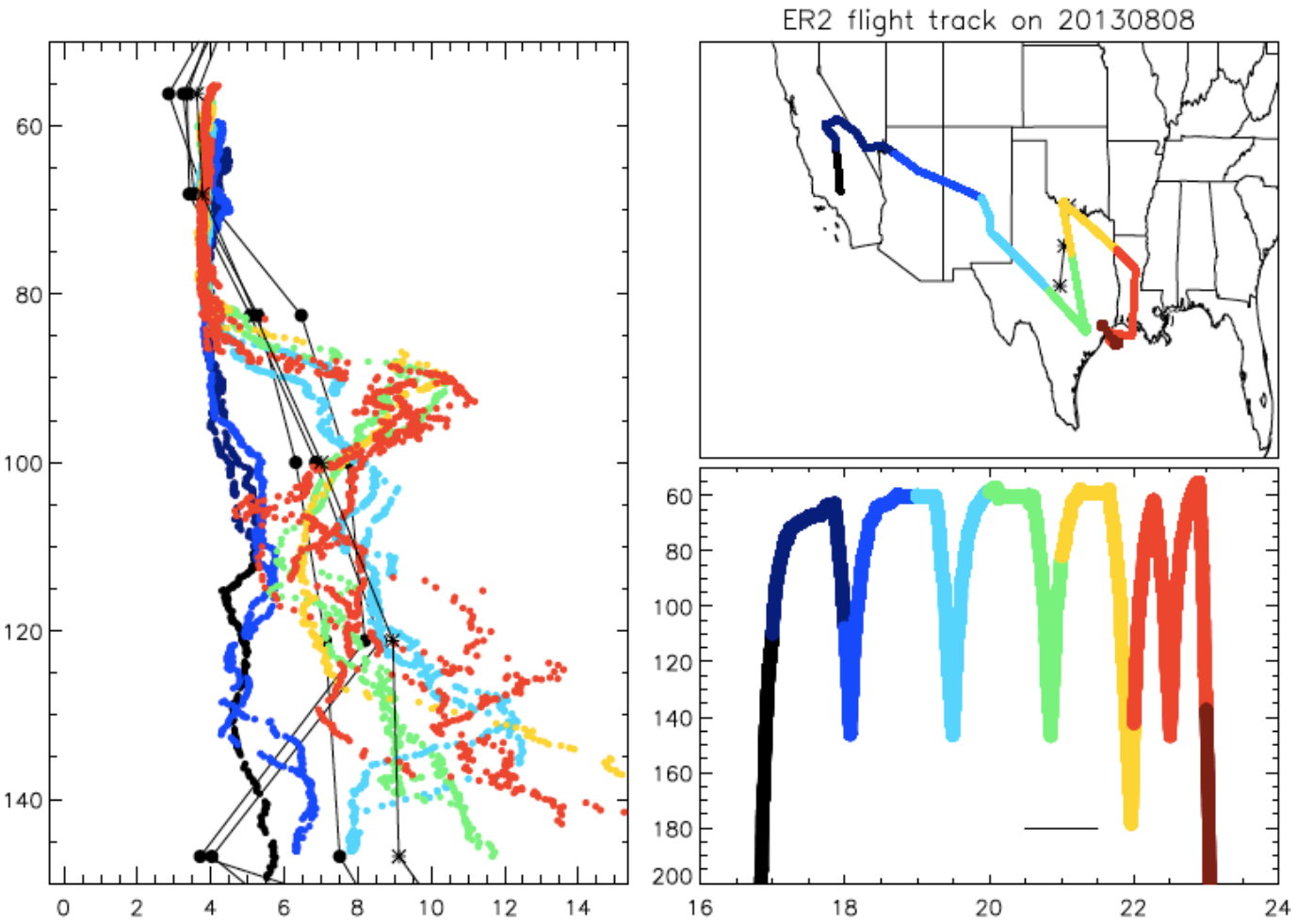

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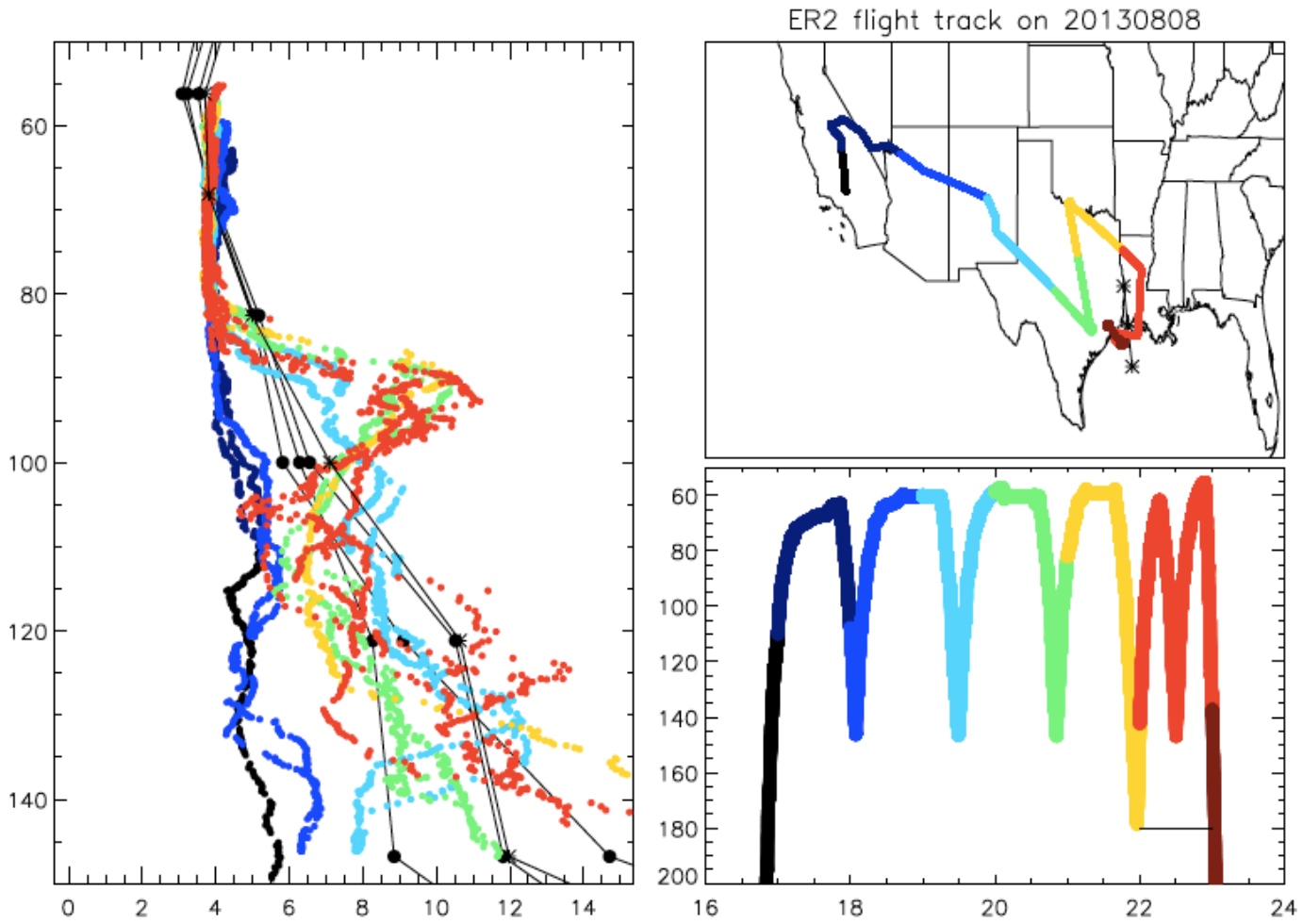

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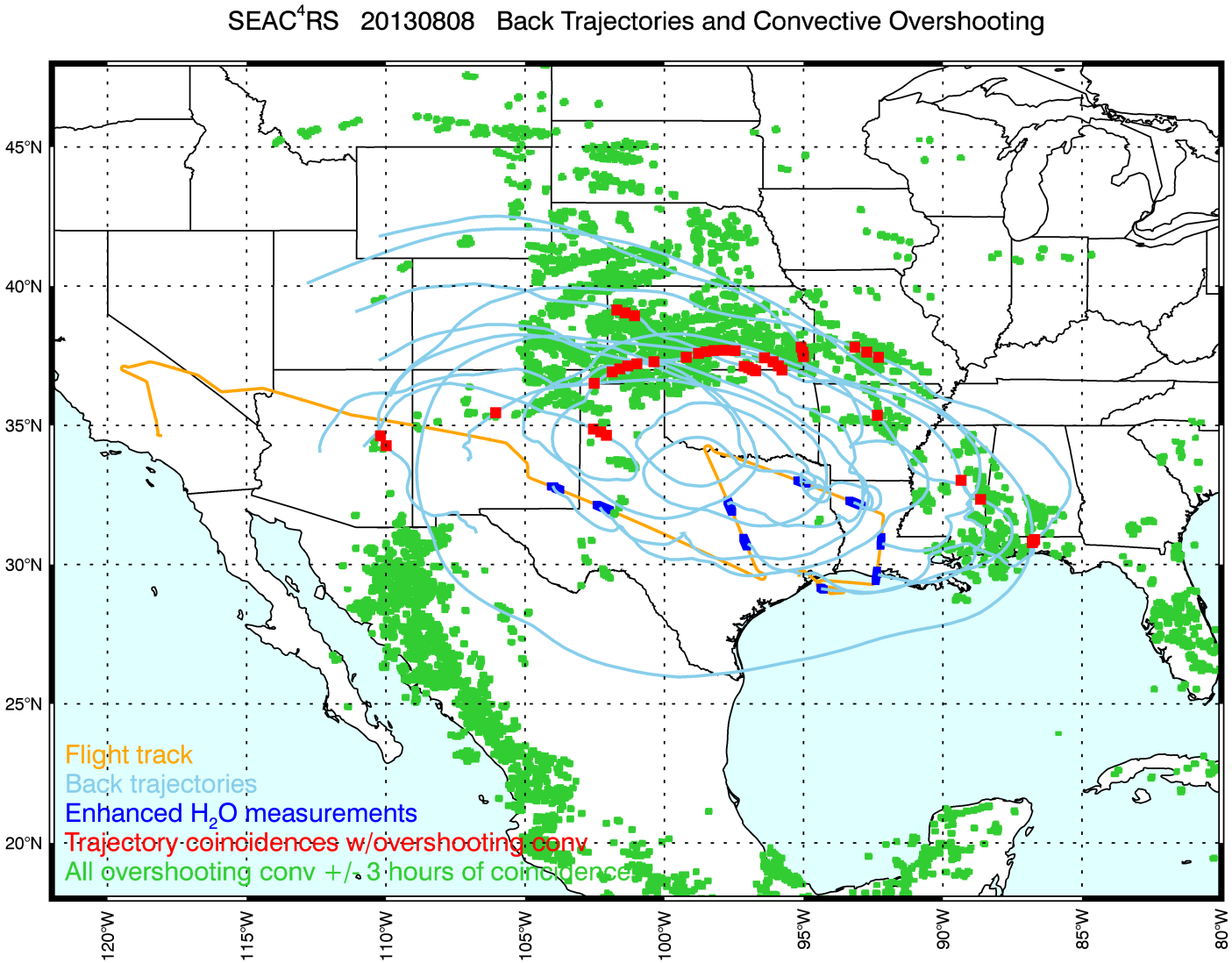
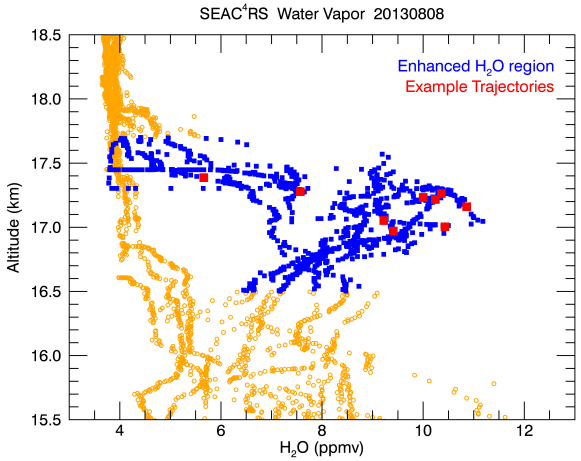
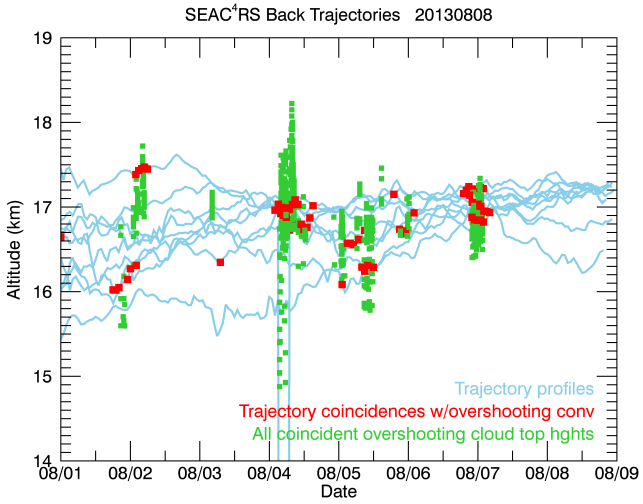
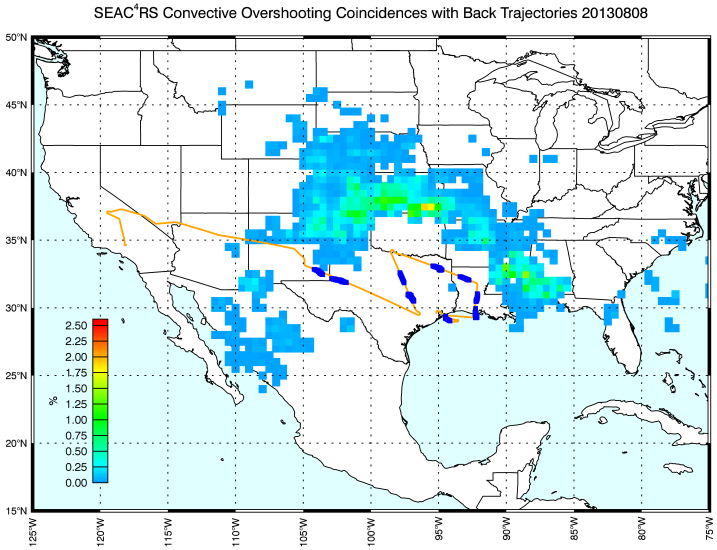


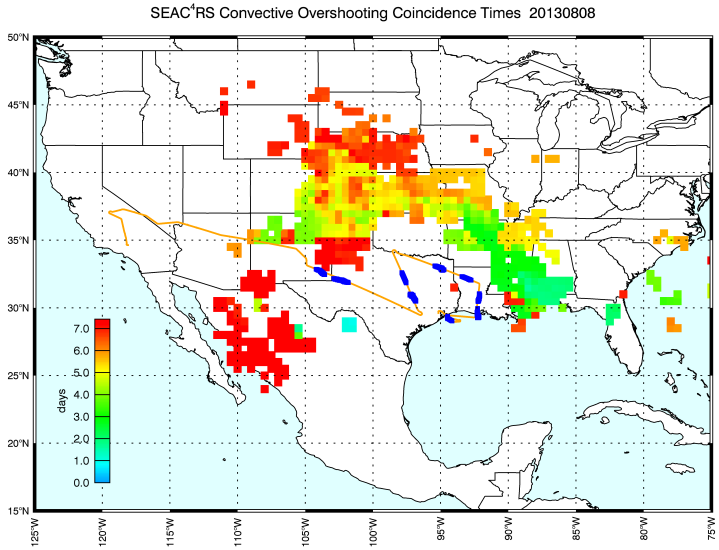
Case Study 1: 08/08/2013 transit flight

Overshooting tops over Great Plains

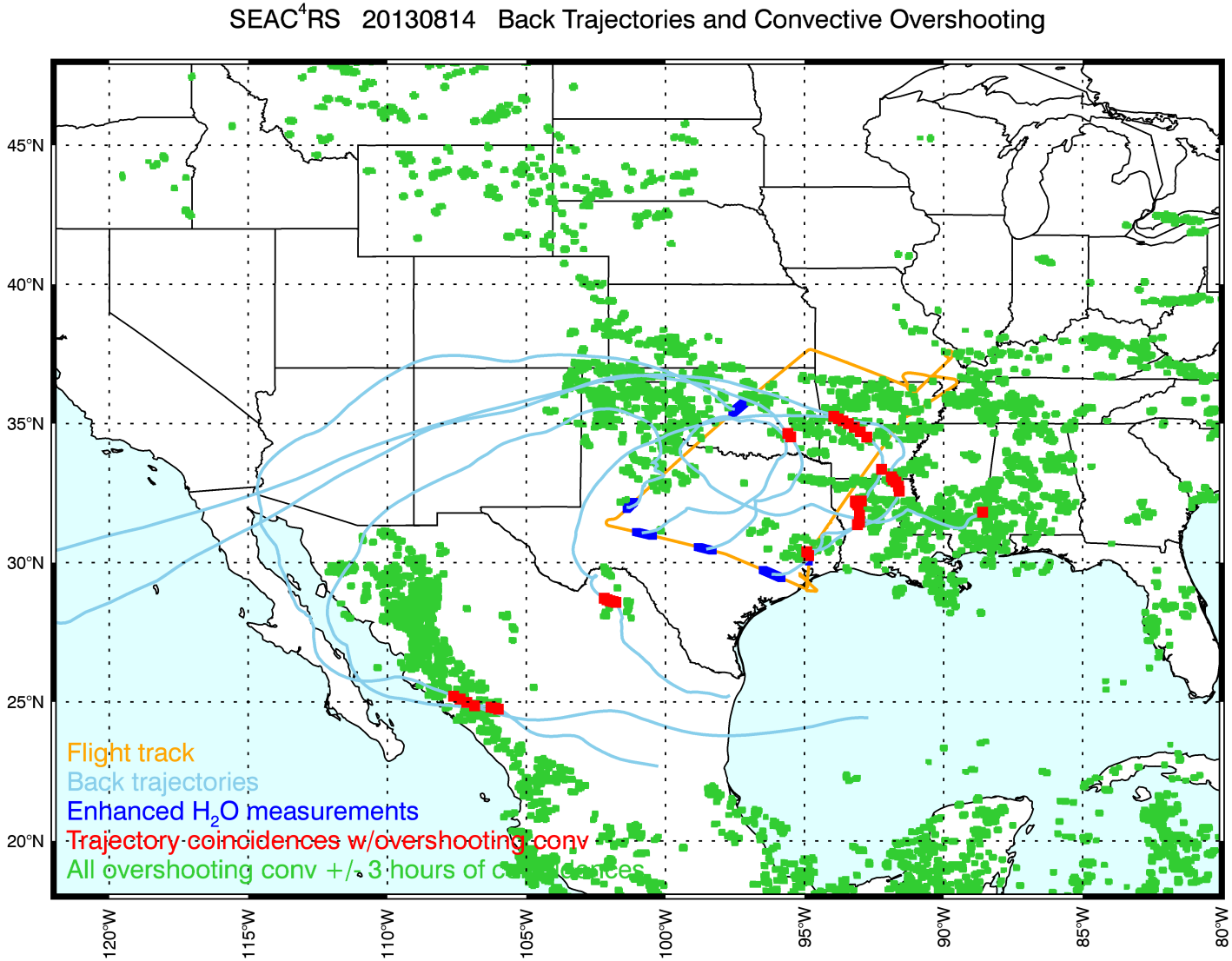






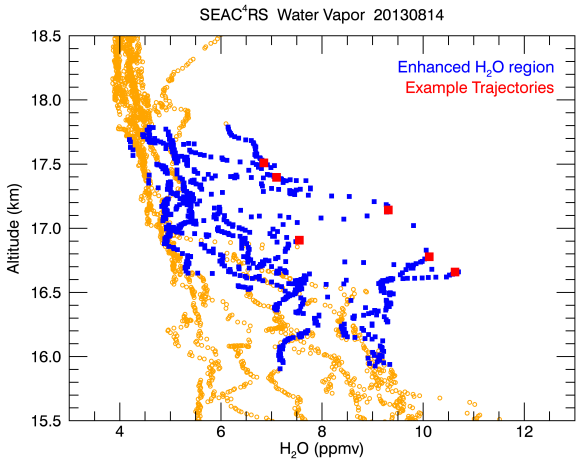


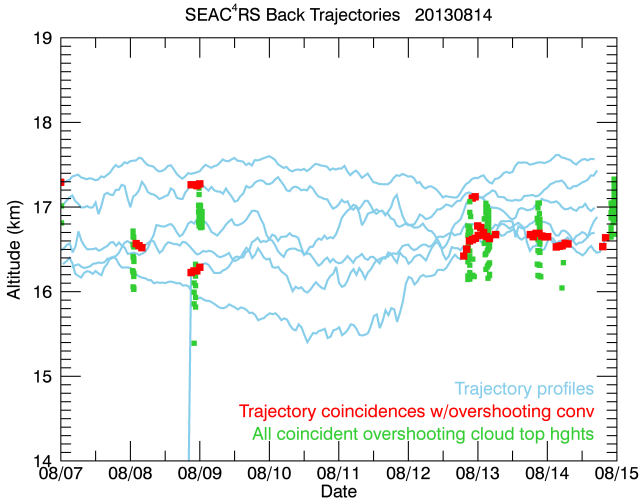
Case Study 2: 08/14/2013

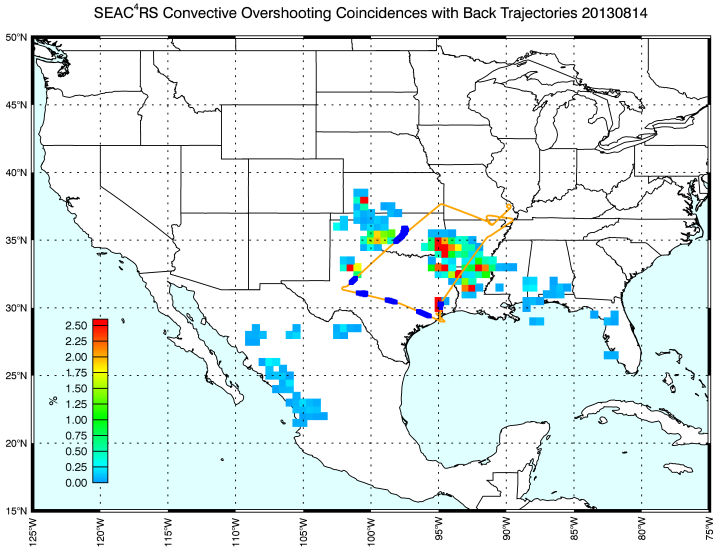


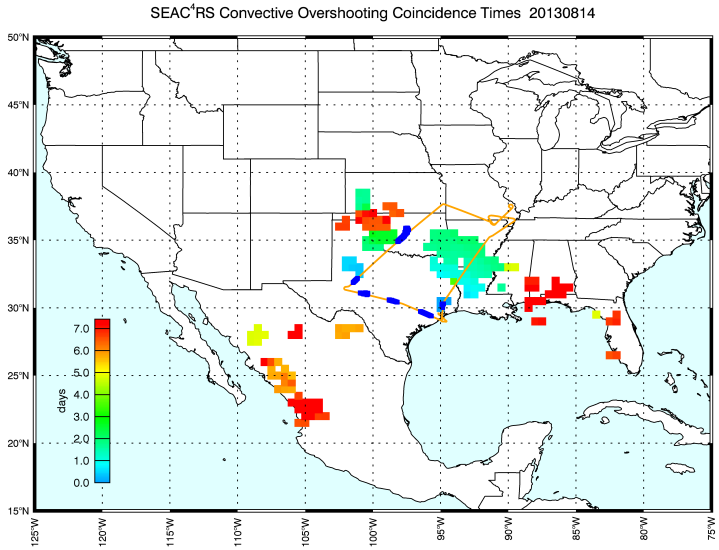
Case Study 2: 08/14/2013

Source from both Mexico and Southern U.S.

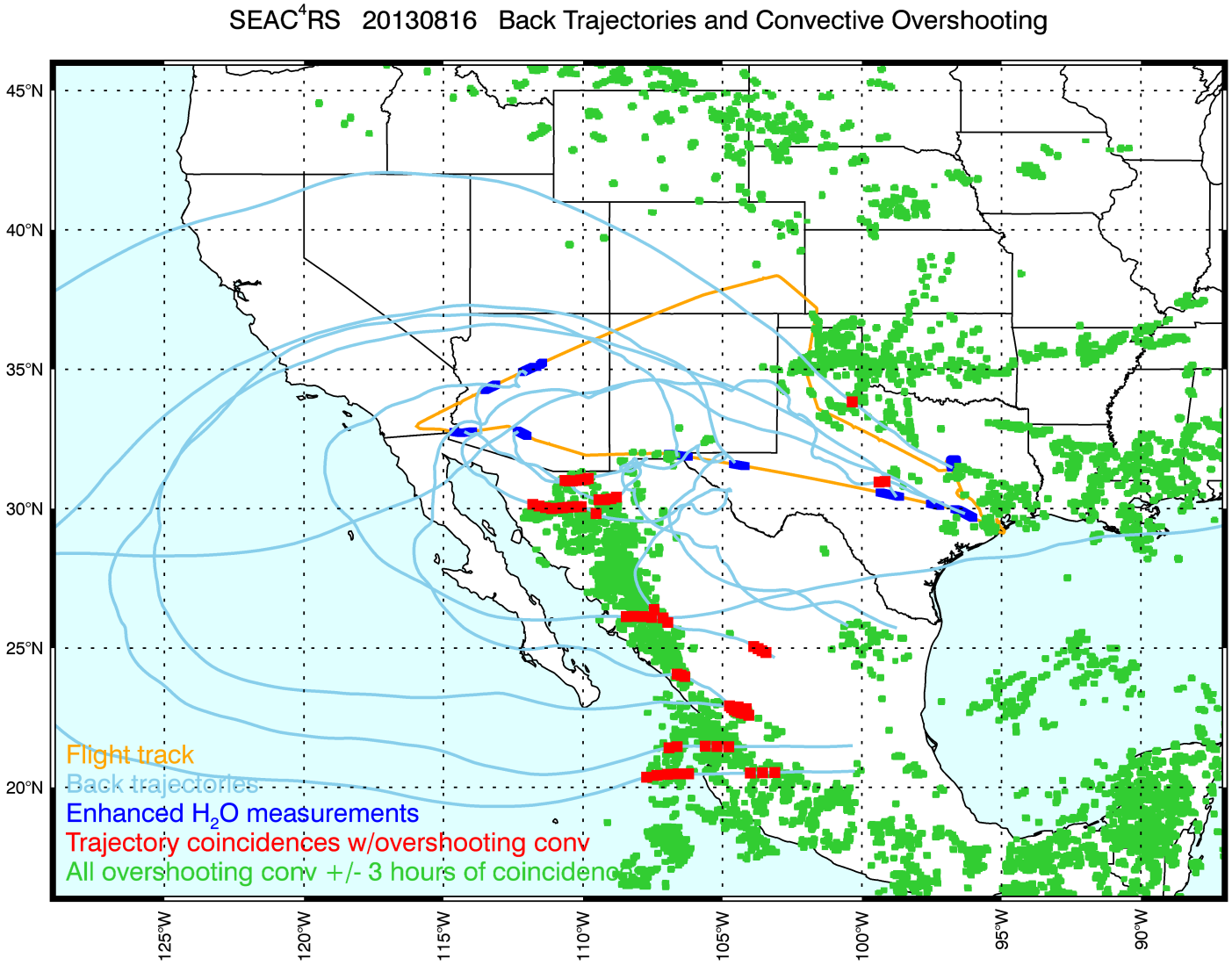






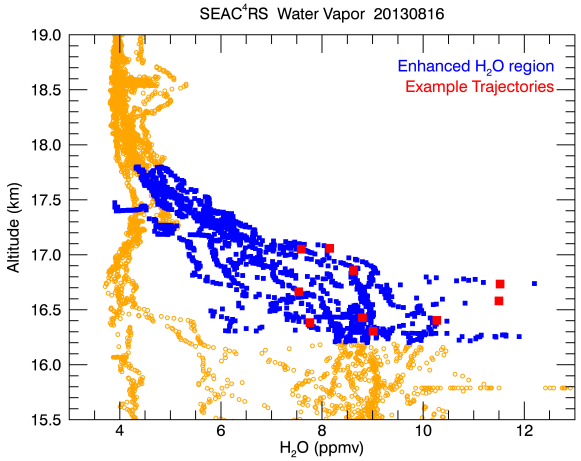


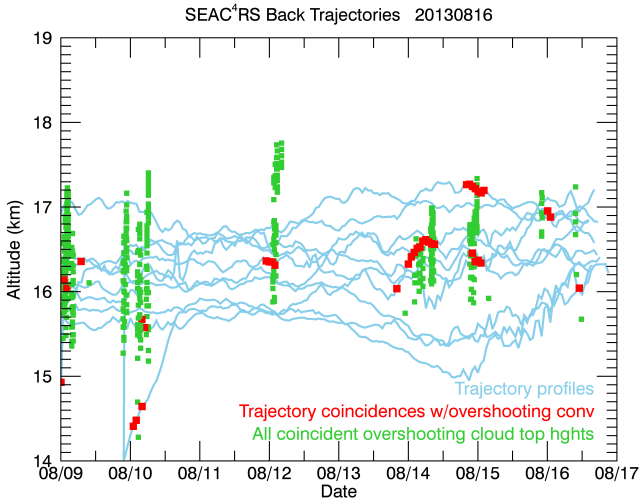
Case Study 1: 08/16/2013

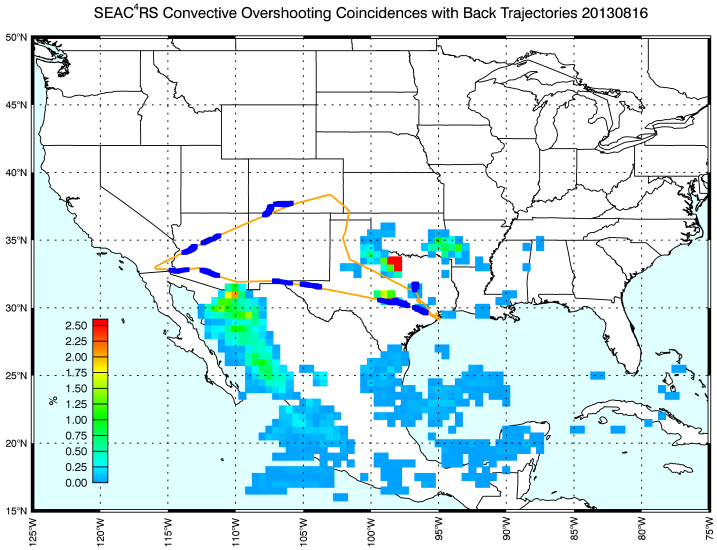


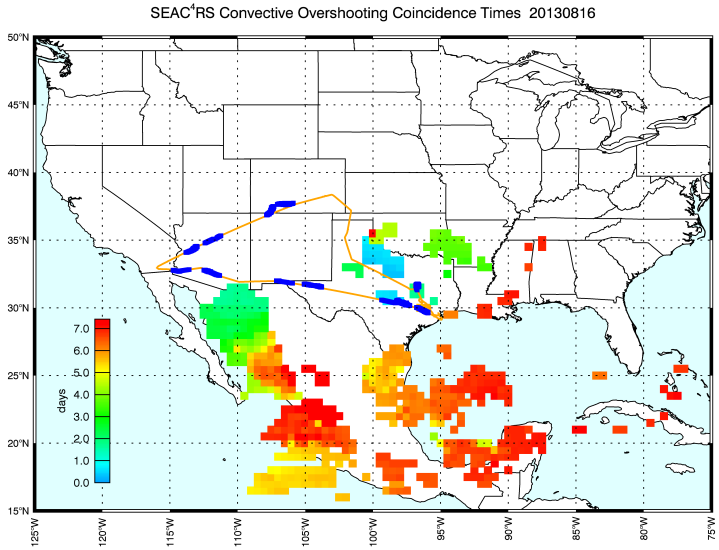
Case Study 3: 08/16/2013

Source from Mexico (Sierra Madre Occidental).

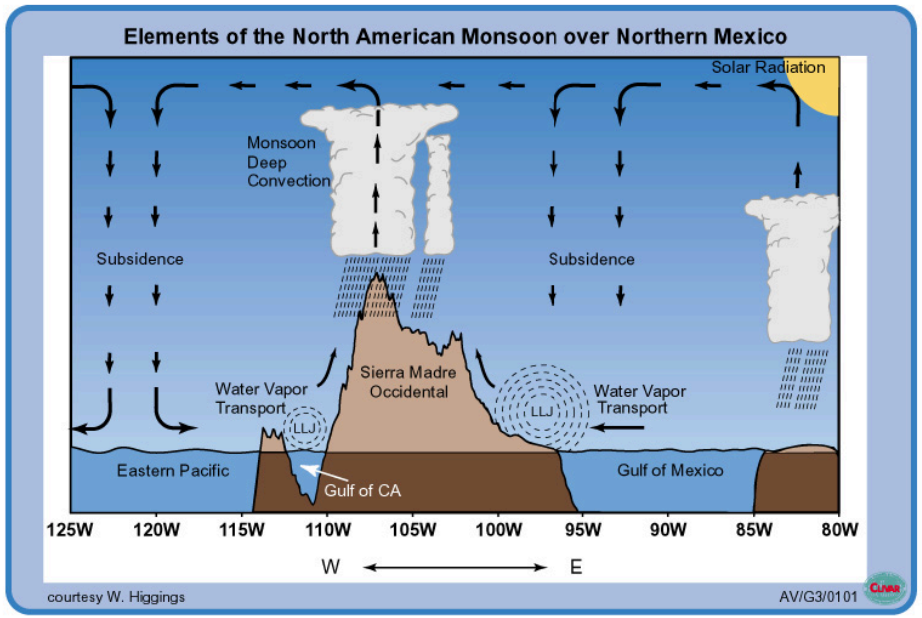








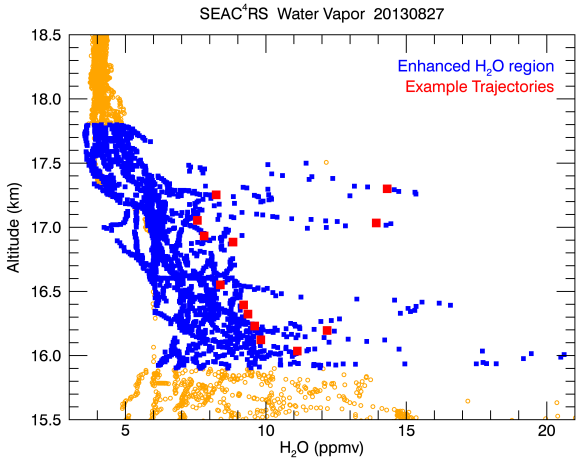
NAM over Northern Mexico

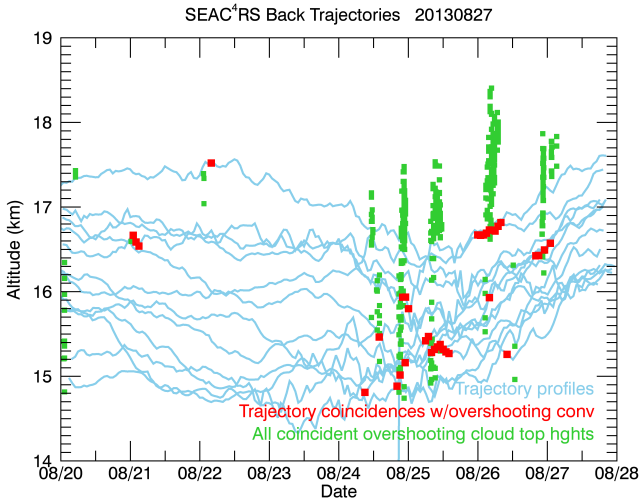


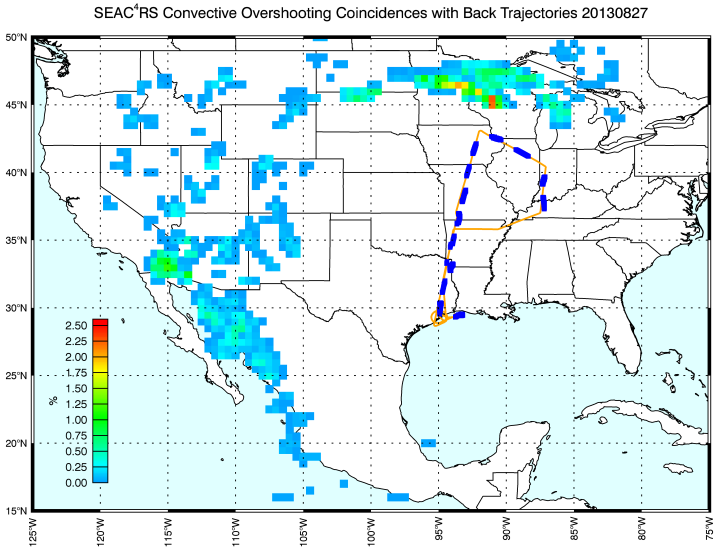
- Figure from “The North American Monsoon. Reports to the Nation on our Changing Planet” (2004).

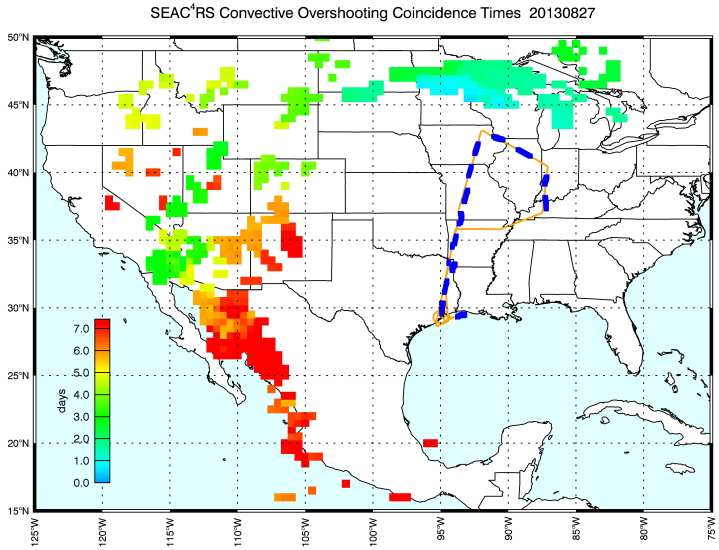
Case Study 4: 08/27/2013

Source from Upper Midwest (Jessica Smith's case study)









Summary

- JLH provided UT/LS water vapor measurements from the NASA ER-2 during SEAC4RS.
- Aura MLS indicates 2013 was drier at 100 hPa than the average of 2004-2013 summers.
- MLS 100-hPa H_2O was observed to exceed 8 ppmv only nine times over the CONUS in July-August 2013.
- JLH frequently observed enhanced H_2O in the lowermost stratosphere between 160 and 80 hPa.
- Back-trajectories connect these air parcels to overshooting convective tops 1 to 7 days earlier.

Acknowledgments

JLH participation in SEAC4RS was funded by the NASA Upper Atmosphere Research Program. We thank Patrick Minnis for the use of cloud images, Laura Pan for helpful discussions, Jose Landeros for field support, and the NASA ER-2 pilots and crew for making these measurements possible. Part of this research was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with NASA.

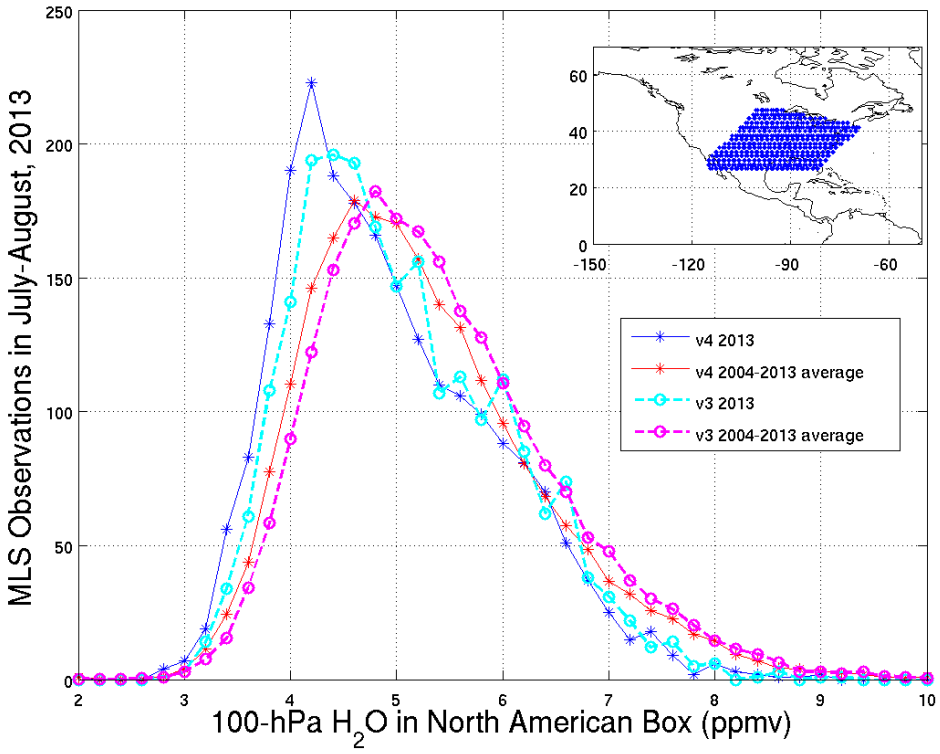
Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov

Backup Slides

Histogram of moisture at 100 hPa

Aura MLS versions 3.4 and 4.2 H_2O



- Aura MLS version 4.2 is slightly drier at 100 hPa than version 3.4 by ~ 0.1 ppmv.

SEAC4RS

Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys